

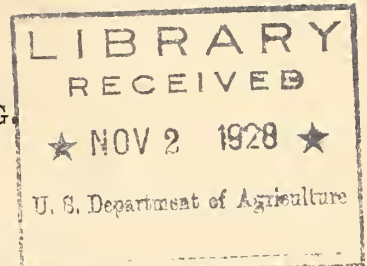
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METEOROLOGY AS AN AID TO SAFE FLYING.

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The vital importance of an adequate weather service for aeronautics is no longer a subject for debate. It is universally recognized. Striking evidence of this fact comes in daily. Insistent requests - many of them in the form of demands - for more service are received with every mail from all parts of the country, - from the lowly hamlet as well as the mighty metropolis. Caustic are the comments when these truly air-minded people are told - as many of them must, under present conditions, be told - that no funds are available for granting their requests.

A leading Air Mail contractor is authority for the statement that all of the troubles experienced by his company in the course of a single year were directly or indirectly traceable to weather. And, more recently, the president of the Transcontinental Air Transport Co., has stated that, in the maintenance of schedules in the proposed rail and air service from coast to coast, "everything will depend on the weather."

Other testimony to the universal recognition of the need for weather service is the inauguration during the past two years, by the Government, of such detailed service as funds permit on all of the commercial airways; and, quite recently, the organization by the Guggenheim Fund of an experimental, very detailed and intensive, service between San Francisco and Los Angeles.

The importance of weather service for aeronautics may be considered from two points of view, - that of safety and that of efficiency. The latter will loom larger and larger as time goes on, but this National Congress is devoting its attention to safety, and this paper will therefore be confined to that phase of the subject. In it will be discussed briefly the following topics:

1. Present status of airway weather service.
2. Needed researches.
3. How the pilot can cooperate.
4. How the air transport operator can cooperate.

1. PRESENT STATUS. Briefly stated, weather service for aeronautics, as now organized, may be said to be in the pioneer stage. We are trying out many different schemes. We hope and believe that some of them are along the right lines, but only time and experience can tell with certainty as to this.

Since 1926, when the Air Commerce Act was passed, service in greater or less detail, depending upon the amount of air traffic, has been organized along all of the commercial airways that have been established or recognized as such by the Department of Commerce. This new service is of course an

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extension of that already existing for the general public, which consists of twice-daily reports from all parts of the country and forecasts based thereon, these forecasts covering periods of 12 to 36 hours.

Although this service was very early found to be of a too general character to suit the needs of fliers, it did provide the groundwork or parent organization, and, as such, was capable of expansion at comparatively little additional cost. One of the first acts in making this expansion was to increase the number of what we may call "upper air" stations, that is, those at which observations are made of winds at flying levels. In all, there are now some 50 such stations, well distributed over the country, many of them being located at important points on the airways themselves.

Information regarding upper wind directions and velocities, although helpful in enabling the pilot to select the most favorable flying level, is not vital in the same degree as is similar information concerning conditions at the surface. It is this latter information that determines whether or not any flight at all can be made. Fog, low-lying clouds, excessive rain, sleet or snow, severe thunderstorms and very poor visibility render flying hazardous and impracticable. Not always will this be so, but in the present state of the art it is. Therefore, particular attention is given to these conditions, not only at the upper air stations but also at numerous places where observations are confined to surface weather. In all, there are now approximately 150 stations, most of them on the airways, from which such reports are available, when needed. Naturally, the time when they are needed is just before the pilot begins his flight. Accordingly the reports are in general sent as short a time before the take-off as possible and still assure their receipt in time for use. Of course, the ideal system would be an exchange of reports all along an airway and from points on each side of it at frequent, regular intervals. But, at the present time, available funds do not permit this, and in some cases it is not yet justified, owing to the small amount of traffic that has thus far developed. However, there is now a three-hourly exchange of reports between the principal points on the New York-Chicago airway, supplemented by special reports to fit the flight schedules from these and intermediate points on this airway. Moreover, as previously stated, an experimental service has been organized by the Guggenheim Fund between San Francisco and Los Angeles, and in this service frequent reports at regular intervals are interchanged between a large number of stations, both on and off the airway.

The reports themselves contain information regarding the general character of the weather, as clear, overcast, rain, snow, etc; ceiling or height of low clouds; visibility; wind direction and velocity; temperature and pressure; and, when available, upper wind data. These reports go to the meteorologist who in many cases has his offices at the airport. They are used by him not only in giving out information concerning current conditions, but also as a basis for short-range airway forecasts for the following one to five or six hours, depending upon the length of the flight. The utility of these short-range forecasts is becoming increasingly evident.

It is no exaggeration to say that, in the early days of flying, pilots in general paid comparatively little attention to forecasts, unless a very long flight was contemplated. For short trips current reports were deemed sufficient. Many experiences, however, some of them involving considerable hazard and a few of them resulting in accidents, have shown very clearly that a condition reported as existing at any given time may, and often does change decidedly in the course of so short a period as an hour or so. Accordingly, on nearly all airways, the current reports are now supplemented by forecasts of probable changes in existing conditions, with particular reference to type of weather, ceiling and visibility.

It should be distinctly understood that neither in the current reports nor in the forecasts does the meteorologist tell the pilots whether or not they should fly. His function is, and must always be, only to describe the weather itself and give his opinion as to what it will be in the next few hours, leaving to the pilot or to others in control of the airways operations the decision as to the favorableness or unfavorableness of that weather for flight. The wisdom of this policy is apparent when one considers that the appraisal of weather conditions in relation to flight is to a considerable extent a relative one, depending on the experience and temperament of the pilots, the type of aircraft and the character of the service. Some pilots do not hesitate to start out in weather that others regard as offering considerable risk. Again, a strong head wind is or is not serious, depending upon the speed and cruising radius of the craft that is to fly against it. Finally, greater caution should be exercised with a passenger-carrying than with a mail or express service. These considerations introduce uncertainties with which the meteorologist, with his usually limited flying experience, is not equipped to deal. He indeed has his own quite sufficient responsibility of saying what the weather itself will be.

In addition to the current reports and short range forecasts, the service to civil aeronautics provides forecasts covering periods of 12 to 24 hr more hours. These are the general forecasts, augmented to include upper winds. They are of necessity couched in more general terms than are the short period forecasts. In commercial aeronautics regular schedules must be maintained so far as possible. The operator wants to know today the likelihood of making a scheduled flight tomorrow. Particularly is this true in passenger-carrying service. If the probability is that no flight can be made or that there will be considerable delay, the prospective passenger can be so informed and can then, if he so desires, make his trip by train or bus. It seems likely that these longer period forecasts will become more and more important as the service develops.

All of this service - current reports and forecasts alike - is of little use unless it provides up-to-the-minute information to those needing it. This type of service involves two requirements: 1st, close contact between pilot and meteorologist; 2d, prompt and dependable means of communication. For the former it has been found by experience that the most satisfactory arrangement is to have the weather service organized and furnished

right at the place where the pilot starts on his flight. And that place of course is the airport. Not only does the pilot thus get the reports as soon as they are received but he also is able to discuss them with the meteorologist. This matter of personal contact looms larger day by day as a prerequisite for the best possible service. When the weather outlook is decidedly uncertain (and alas! there are many occasions of the sort to plague the meteorologist) it is tremendously helpful to the pilot just simply to talk the situation over with one who makes a special study of weather and its vagaries. It is now a regular part of the Government's policy to establish service at airports. This has been done in several cases and provides 24-hour service where flying is carried on both day and night. It will be extended to other important airports as the need develops and facilities permit.

But the meteorologist himself is handicapped unless he also receives promptly the reports from points along the airway and elsewhere on which he bases his bulletins and forecasts. And this means a dependable system of communications. Whatever the most satisfactory method may eventually prove to be - radio, telegraph, telephone, typewriter printer, or perhaps something unknown to us now, it will prove its adequacy for the purpose only by showing that it gets the information through more speedily and more dependably than does any other method. Very likely no one method will be used to the exclusion of all others, but one may be the principal, and the others auxiliary, means of communication. All types are at present in more or less general use in the service.

In addition to these ground communication systems there must be means of signalling to aircraft in flight. No matter how detailed a weather service, or how able the meteorologist, there will always be occasions (we hope their number will become progressively smaller) when conditions will unexpectedly change from favorable to unfavorable or vice versa after the flight has started. The pilot must then be informed - by radio if the aircraft is suitably equipped; otherwise by visual means. So-called panel signal systems are now being tried out at certain critical points in different parts of the country and much experimental work is also being conducted in developing suitable apparatus for ground to plane communication.

Such in brief is the present status of aeronautical meteorology, so far as its practical application is concerned. Although it is true that only a beginning has been made, it is believed that that beginning is along correct lines. If so, then future developments will be in the nature of marked extension rather than radical change. And that extension will include all sections of this country and its possessions.

2. RESEARCH. Much has been learned in the course of the past 100 years, concerning the general characteristics of the atmosphere. During the last 30 years our knowledge has been extended very considerably into the regions above the earth's surface. The general structure of the atmosphere is fairly well known up to 20 miles, well above present-day flying levels. And yet it can truly be said that an almost unlimited field for research lies open before us. The surface has scarcely been scratched. We are not

so much concerned with general characteristics. What we want to know more in detail are the special occurrences, many of them of small extent but of serious import to the flier.

Meteorological research has suffered greatly from indifference on the part of educational institutions and from the limited field available to those who might take it up as their life work. Happily the situation is materially improving. With the development of aeronautics there is a growing demand for thoroughly trained meteorologists. To meet this demand some of our leading colleges and universities are organizing courses in meteorology which will be of a grade similar to that of courses leading to degrees in other technical and scientific professions. It seems well, therefore, to consider some of the lines in which research is desirable as a means of increasing safety in flying. A few of the more pressing problems will be briefly discussed.

Visibility is the one great concern of the pilot. In proportion as it decreases his troubles increase. It reaches the vanishing point in dense fog. It is not for the meteorologist to try to get rid of fog. But he must study, in a detail that has never yet been attempted, the conditions that produce it, and those that dissolve it. True, we have this knowledge in a general way, now, but we can't apply it in individual cases. Otherwise, the forecasting of fog would now be a success; instead it is a failure, if we consider forecasting in anything like a specific way with regard to time and place.

Similar study should be made of the occurrence of haze which becomes at times and in some regions so dense as seriously to affect visibility.

Nearly all pilots ask first for information on two elements, visibility and ceiling. Low ceiling simply means that visibility is cut off except at levels which are dangerously low for flying. Studies should be made that will enable the meteorologist to forecast the formation of low clouds with a goodly degree of precision as to time and area. Probably for such forecasts information as to upper air temperature, humidity and wind will be necessary.

This leads to the subject of new and improved methods of procuring upper air data. At present our knowledge of wind conditions is derived for the most part from observations with small balloons, which can be used only in clear weather. There is urgent need of developing instrumental or other means for sounding the upper levels more or less continuously, and certainly at times when conditions are unfavorable or are becoming unfavorable.

This seems to be a requirement particularly in the forecasting of conditions favorable for the formation of ice on aircraft. In this connection it may be stated that a preliminary investigation of this subject will be made during the next few months.

Aside from fog, low ceiling and ice formation there are numerous subjects which are of less importance, but a better knowledge of which would nevertheless contribute very decidedly to greater safety in flying. Among them is the formation of the more or less violent disturbances, such as thunderstorms, line squalls, tornadoes, etc. These are usually not difficult to cope

with, providing their occurrence is known, with a reasonable degree of precision, in advance. Much more needs to be known than at present is known concerning gustiness and vertical convection, both near the surface and at considerable heights. In fact, there is very little knowledge of the extent of vertical movements in the upper levels, such as those that were responsible for the destruction of the Shenandoah. Studies of this subject are of special concern in connection with the design and operation of lighter-than-air craft.

Finally, there is much work to be done along statistical lines. We have already gathered together an immense amount of data and we are adding to this supply daily. Most of this has been so compiled as to be quickly and conveniently available for study. There are many lines along which such study would be profitable. For example, an operating company must adopt a schedule that is as fast as possible and one that can be maintained a fairly large percentage of the time. There are two principal factors that determine what that schedule can be. One is the cruising speed of the aircraft employed and the other is the weather. The data concerning frequency of head and cross winds, fog, low clouds, heavy snow and sleet, etc., would determine what schedule could be kept, say 90 per cent of the time. Such studies have been made and published for two of the important airways. Data already available are sufficient for similar studies as to workable schedules for nearly all of the airways. Naturally, the results can not be used to predict schedule maintenance for a short period, such as a week or a month. But for periods of a year or longer they would be (and in the cases cited they have been) found to be very nearly accurate.

3. HOW THE PILOTS CAN COOPERATE. We have already stressed the value of close contact between pilot and meteorologist. Let it be said at once, and the statement is based upon abundant experience, that the benefit is by no means one-sided. The pilot, in his discussions with the meteorologist, gets help that is immediate and direct. He profits by it that day and is then through with it. But the meteorologist learns from the pilot, if the latter be a good observer, many things that enable him greatly to increase the value of his own service. For one thing he learns the pilot's viewpoint - comes to know what he is most concerned about. In many cases in which the meteorologist is uncertain as to what the weather will be, the pilot tells him after the flight just what it was. This information often is available in no other way. The meteorologist finds out whether his prediction failed or succeeded, and is better equipped to handle the next similar case.

Oftentimes, moreover, a pilot brings in information which is of great aid to another pilot who is about to start in the opposite direction over the same route. This information supplements, in a most helpful way, the data obtained from other sources.

Accounts of experiences in particularly bad conditions, for example in a squall or while ice is forming, give the meteorologist valuable data for not only the day to day service but also for purposes of research.

In short, it appears that the pilot's contribution toward making the weather service play a dominant part in increasing the safety of flying will be more^{or}less effective in proportion as he and the meteorologist discuss, frankly and sympathetically, their mutual problems. In this way each one profits and, more important, the safety and efficiency of flying are increased.

4. HOW THE OPERATOR CAN COOPERATE. In many respects it is the air transport operator who is most vitally interested in this whole matter of safety. He must be able to guarantee a reasonable degree of it in the service, that he operates; otherwise, his ledger will very shortly show a balance on the wrong side. He knows full well that, every time a crash occurs and particularly every time a life is lost, the whole program of the development of commercial aeronautics suffers a setback, entirely out of proportion to the seriousness of that single accident. It is the operator, therefore, from whom we should expect to receive the most effective cooperation in helping to make the weather service do its share in increasing the safety of flying.

He can do this in several ways. For one thing, he can arrange to have the meteorologist accompany the company's pilots on some of their regular trips. Experience shows that in no other way does the meteorologist obtain so clear a grasp of the pilot's problems as through actual flights in the different types of weather in which flights must be made. Poor visibility and low ceiling are terms that acquire a meaning then that they had not theretofore had. The two men learn, through these flights together, to talk a common language and can thus the more intelligently discuss their mutual problem.

The flights to which we have been referring are those in the operating company's regular schedule. Oftentimes, a pilot will start with less than a full load and it is then that provision might well be made for the meteorologist to go along. But, in addition, it is believed that special flights should be provided for during conditions of unusual interest. Such flights would not, as a rule, be cross-country, but would be made right at the airport, up to a certain desired height and down again. For example, suppose that conditions in late afternoon appear favorable for ice formation that night when a regular scheduled flight is to be made, but the meteorologist is uncertain because he doesn't know the temperature and humidity at flying levels. A short, special flight, 20 minutes in length perhaps, would secure these data and enable the meteorologist to tell with more certainty than he otherwise could whether or not a flight should be attempted. Occasional cooperation of this sort from the operator would, it is believed, contribute very decidedly at times to the safety of flying.

Finally, the operator can cooperate very effectively by instructing his pilots to give careful attention to the reports and forecasts that he receives from the meteorologist. He should also at all times be perfectly frank in his criticism of the service. If this service is not dependable,

both the operator and the pilot owe it to themselves, to their patrons and to the Government to report that fact to headquarters in order that action can be taken to bring about improvement.

It is proper, and it is also a pleasure, at this point to say that co-operation on the part of the air transport companies' officials, pilots, operators and others, has been and is whole-hearted and most helpful. Probably more appreciative attention is given to the weather service than to any other feature of the aids provided by the Government. And in return the facilities of these companies, almost without exception, have been made available to the meteorologists, many of whom now make occasional flights without cost to themselves or the Government.

SUMMARY AND CONCLUSIONS. Meteorology can help make flying more safe in the following ways:

1. Through an intensification of the service already organized, so as to provide -
 - a. More frequent reports from a larger number of stations;
 - b. More frequent and accurate airway forecasts;
 - c. A prompt and dependable system of communications, including ground to plane.
2. Through research conducted by properly trained men in -
 - a. The conditions favorable for the formation and for the dissipation of fog, haze and low clouds;
 - b. The development of additional methods for making observations of upper air conditions in all types of weather;
 - c. The conditions favorable for the formation of ice on aircraft;
 - d. The conditions favorable for the development of gustiness, vertical movements and violent disturbances such as thunderstorms and line squalls;
 - e. Statistical data from which can be determined many useful facts, such as the approximate schedules that can be guaranteed for different parts of the country.
3. Through cooperation on the part of the pilot in -
 - a. Discussing frankly with the meteorologist the problems with which he has to deal;

- b. Telling the meteorologist whether or not his forecasts are correct, and, if not, wherein they failed;
 - c. Describing to the meteorologist the conditions through which he passes that give him most concern.
4. Through cooperation on the part of the operator in -
- a. Making suitable arrangements for the meteorologist to accompany the pilot in some of his regular flights;
 - b. Providing special flights during particularly interesting conditions;
 - c. Instructing the pilots to pay close attention to the weather reports and forecasts;
 - d. Criticising frankly the service furnished, in order that it may be developed to the highest possible point of efficiency.

THE FUTURE. Those of us who believe thoroughly in the future of aeronautics, and the number is happily growing by leaps and bounds, foresee a development in the not distant future when it will occupy a prominent place in the commercial life of the nation, not supplanting but supplementing in a large way other types of transportation. This development means a similar expansion and intensification of weather service. Such a service is possible, but, to be most effective, it must have the whole-hearted support of pilots and operators, it must be made more nearly perfect through research, and it must be of the up-to-the minute type through a fast and dependable system of communications. With such a service functioning on all of the airways, the hazards of flight which now unfortunately, and in a large measure unjustifiably, loom large in the public consciousness will vanish, and aeronautics will truly "come into its own."

